Management and within-tree spatial distribution of the small red-belted clearwing borer, *Synanthedon myopaeformis* (Borkhausen) (Lepidoptera: Sesiidae), infesting dwarfing apple orchards in southern Jordan

MAZEN A. ATEYYAT[1,3] and TAWFIQ M. AL-ANTARY[2]

ABSTRACT

Experiments were conducted in the Ash-Shoubak apple-growing region of southern Jordan to determine the impact of four management practices on reducing populations of the small red-belted clearwing borer, *Synanthedon myopaeformis* (Borkhausen) infesting apple cultivars grafted on M26, M109, and M106 rootstocks. Results revealed that use of a flexible wire to mechanically kill insect larvae, mounding soil over the graft-union area, wrapping tree trunks with cheesecloth from the soil surface to a height of 80 cm, and use of an insecticidal paint composed of water, copper sulfate, petroleum oil, and Durusban®, all reduced the insect populations compared with untreated control trees. The insecticidal paint treatment caused the greatest population reduction. More *S. myopaeformis* larvae were recovered from the main trunk of the trees than from main and sub-main lateral branches.

Key Words: Sessiidae, pome fruits, burr knots, clonal rootstocks, cultural control, chemical control, Mondial Gala

INTRODUCTION

Since the late 1980s, the small red-belted clearwing borer (RBB), *Synanthedon myopaeformis* (Borkhausen) (Lepidoptera: Sesiidae), also known as apple clearwing moth, has become an increasingly important indirect pest of apple, *Malus domestica* Borkhausen (Rosaceae), in Jordan (Al-Antary *et al.* 2004). In Europe before the 1960's, the RBB was considered a secondary pest, which usually attacked apple trees weakened by other factors. However, since the 1960's, the RBB has been considered a serious pest of commercial European apple and pear orchards (Maini and Pasqualini 1980) where a RBB infestation of apples in Germany resulted in a 22.1% decline in yield over a two-year period (Dickler 1976). The RBB was reported as a new pest of apple trees in British Columbia Canada in 2006 (Philip 2006).

The RBB was first discovered in the Ash-Shoubak area of Jordan in the late 1980's (Al-Antary *et al.* 2004), the country's most important area of commercial apple production. RBB has been observed attacking apple trees in neighboring Egypt (Abd Elkader and Zaklama 1971) but its presence in Jordan is the first record of this species in Asia. In 2003, all sixteen commercial Jordanian apple orchards screened for the RBB were found to have at least one cultivar of apple trees infested (Ateyyat *et al.* 2005). The RBB is not found in apple orchards in northern Jordan and this difference may be attributed to the increasing use of clonal, size-controlling rootstocks in high-density orchards in the Ash-Shoubak region (Balazs *et al.* 1996). A similar situation was recorded in eastern North America where the dogwood borer, *Synanthedon*

[1] Department of Agricultural Sciences, Ash-Shoubak University College, Al-Balqa' Applied University, Al-Salt 19117, Jordan
[2] Department of Plant Protection, Faculty of Agriculture, The University of Jordan, Amman, Jordan
[3] To whom correspondence should be addressed: e-mail: ateyyat@bau.edu.jo

scitula (Harris), has become increasingly important as it infests burr knots on the rootstock of trees planted in high-density orchards (Riedl *et al.* 1985, Warner and Hay 1985, Weires 1986, Pfeiffer and Killan 1999, Kain and Straub 2001). Burr knots are the result of many partially developed initials that form just below the graft union on some dwarfing and semi-dwarfing rootstocks (Rom 1970, 1973). These burr knots appear to be preferred ovipostion sites for female sesiid moths including the RBB (Dickler 1976, Riedl *et al.* 1985, Warner and Hay 1985, Kain and Straub 2001). Generally, sesiid borers cause a slow decline and reduced yields over several years of infestation due to girdling resulting from larvae feeding in the cambial layer (Weires 1986, Bergh and Leskey 2003)

There is little documented research on control measures for RBB. Sontgen and Sengonca (1988) recorded a low level of larval parasitism in Germany, and Deseo and Miller (1985) achieved control of RBB larvae using entomopathogenic nematodes, *Steinernema* spp. in apple orchards trials in Northern Italy.

The main objective of this work was to study the effect of four management practices on populations of RBB. These practices included: (1) destruction of larvae using a flexible wire, (2) painting lower tree trunks with a mixture of water, copper sulfate, petroleum oil, and Durusban® (chlorpyriphos), (3) covering the graft-union area with soil, and (4) wrapping the trunk of trees from the soil surface up to 80 cm of height with a cloth veil. These methods could be helpful in establishing an integrated management program for this destructive insect. The spatial distribution of the RBB within individual trees was also studied.

MATERIALS AND METHODS

Management practices. The influence of four management practices on numbers of RBB larvae was studied on 10-year old apple trees, *Malus domestica cv.* Mondial Gala grafted on M26 rootstock, in Al-Hashlamoun apple orchards (about 120,000 apple trees) in the Ash-Shoubak area 220 km south of Amman, Jordan (elevation ca. 1300 m above sea level). These practices were: (1) use of a flexible wire (40 cm long, 2 mm thick) to mechanically kill, by either twisting or probing the wire, all available larvae of the insect that could be seen on infested wounds or in holes that showed signs of infestation; (2) painting the trunk of trees with a mixture of water, copper sulfate, petroleum oil, and Durusban® (chlorpyriphos) (4 L, 2 kg, 2 L and 40 cc, respectively) from its base up to a height of about 80 cm to poison larvae; (3) a cheese cloth (0.25 mm^2 mesh) veil wrapped once around the main tree trunk from its base up to a height of 80 cm and secured with two thick threads at the base and top; and (4) mounding soil to cover the graft union area. Control trees were not subjected to any practice.

Orchardists were requested not to interfere with any practice so as to keep the selected trees as comparable as possible. All treatments were applied once in July 2003, except the wire treatment that was used monthly. Numbers of larvae were recorded monthly from July 2003 to June 2004. The orchard was subdivided into eight plots. Each plot contained a mixture of apple cultivars grafted on various rootstocks. Treatments were distributed according to a randomized complete block design. Each plot was considered as a block and one tree was selected in each block for each treatment. All treated and control trees were pruned in February 2003 and 2004. Some RBB larvae could be seen directly on the wounds. Parts of the bark that showed signs of infestation were cut, the larvae counted and the wound resealed. Field lenses were used to count early larval instars.

Spatial distribution of larvae within trees. This experiment was conducted on 10-year old apple trees, *M. domestica cv.* Mondial Gala grafted on M26, MM106 and

M9, in Al-Hashlamoun apple orchards. Three plots from the orchard were chosen for conducting the experiment. Each plot was considered as a block. Three trees were chosen randomly from each rootstock. One tree was considered as an experimental unit. Experimental trees were subdivided into three parts, trunk, main lateral and sub-main lateral branches. Also, the trunk was subdivided into three parts that were, 0-25 cm above soil, 26-50 cm above soil, and 51-75 cm above soil. The numbers of RBB larvae were recorded using protocol previously described for management trials, on each tree section in July, August and September 2004.

Statistical analysis. An analysis of variance was used to evaluate data (SAS 2001) after data were exposed to the univariate test of normality. Repeated measures ANOVA was used to analyze the main effects of treatments. Mean separation was made by using Least Significant Differences test (LSD).

The diameter of trunk, main laterals and sub-main laterals of the studied trees was measured using a measuring tape and the Table Curve 2D version 4 Program (Jandel Scientific 1992) was used to find the most suitable equation that describes the relationship between distribution of insect larvae and the diameter of trunk, main laterals and sub-main laterals.

RESULTS

Management practices. Mean numbers of RBB larvae found during monthly examinations from July 2003 through June 2004 on a Mondial Gala apple cultivar grafted on M26 rootstock are presented in Figure 1. During the July 2003 pre-treatment examination there were no significant differences in the numbers of RBB larvae found on treated and control trees. All the tested treatments caused a signifi-

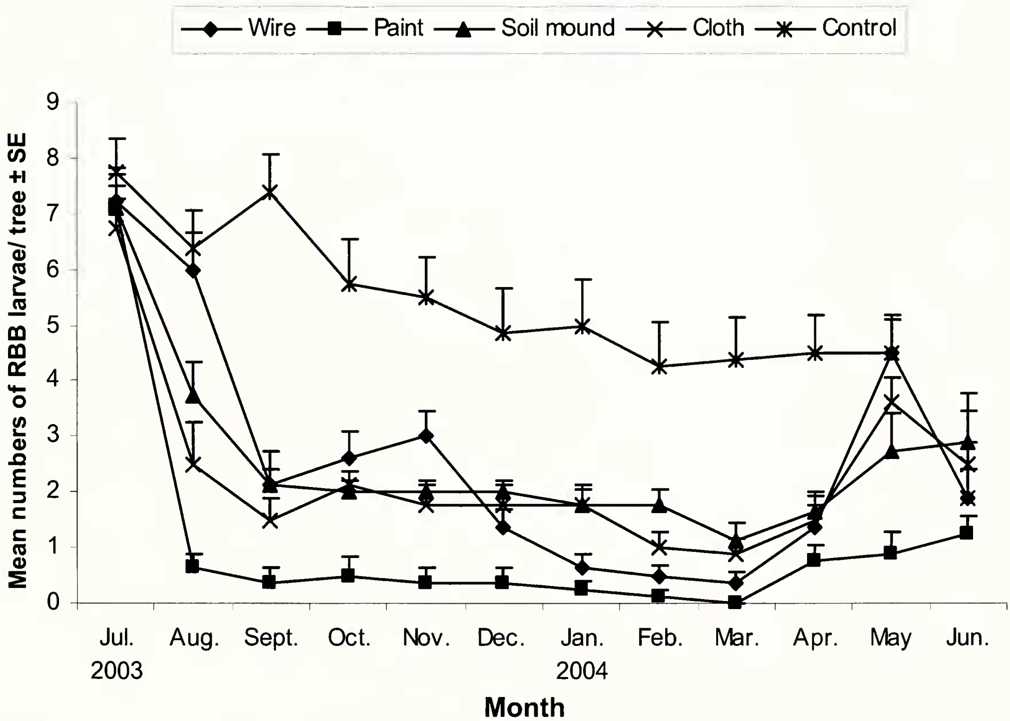

Figure 1. Mean numbers of RBB larvae found during monthly examinations from July 2003 through June 2004 and the effect of the management treatments on a Mondial Gala apple cultivar grafted on M26 rootstock.

Table 1.

Impact of management practices on the mean numbers of small red-belted clearwing borer, *S. myopaeformis* larvae from July 2003 to June 2004 on a Mondial Gala apple cultivar grafted on M26 rootstock. Treatments included (1) using a flexible wire to mechanically kill the larvae, (2) painting the trunk of trees with a mixture of water, copper sulfate, petroleum oil, and Durusban® (chlorpyriphos), (3) mounding soil to cover the graft union area and (4) a cloth veil wrapped around the main tree trunk from its base up to a height of 80 cm. Replicated 8 times, n=1.

Treatment	Mean number of larvae from July 2003 through June 2004	
	July 2003 (Pre-treatment)	Overall efficacy (Post-treatment)
Wire	7.25 a[1] ± 0.59	2.21 b ± 0.23
Paint	7.13 a ± 0.40	0.64 c ± 0.14
Soil mound	7.13 a ± 0.58	2.16 b ± 0.22
Cloth	6.75 a ± 0.53	1.89 b ± 0.28
Control	7.75 a ± 0.59	4.76 a ± 0.37

[1] Means within the same column that have the same letters are not significantly different using Least Significant Differences LSD

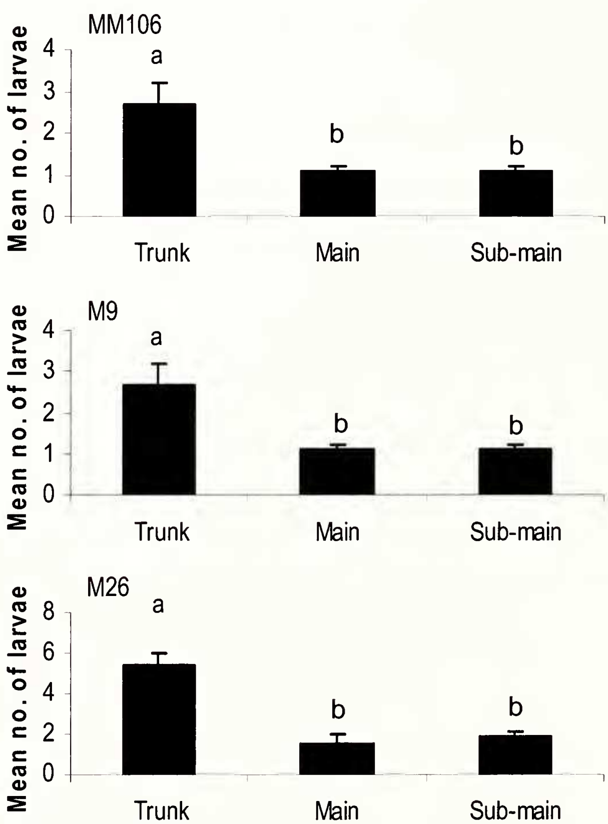

Figure 2. Within-tree spatial distribution of the small red-belted clearwing borer, *S. myopaeformis* larvae infesting the trunk, main and sub-main laterals of Mondial Gala apple cultivar grafted on MM106, M9 and M26 apple rootstocks. Means with the same letters are not significantly different using LSD.

cant reduction in the populations of this insect in subsequent samples (F = 19.63; df = 4, 35; P = 0.0001) (Fig. 1, Table 1) and the insecticidal paint treatment caused the greatest reduction (Table 1).

Within-tree spatial distribution of larvae. The numbers of larvae recovered in samples of the trunk, main and sub-main lateral branches of Mondial Gala apple cultivar grafted on MM106, M9 and M26 apple rootstocks are presented in Figure 2. RBB larvae were most often recovered from the trunks of trees compared with numbers found on the main and sub-main lateral branches (MM106: F = 8.60; df = 2,6; P = 0.0173; M9: F = 25.13; df = 2,6; P = 0.0012; M26: F = 15.10, df = 2,6; P = 0.0046) (Fig. 2). Within these trunk samples however, there were no significant differences in the numbers of larvae recovered from different subsections (0-25, 26-50 and 51-75 cm above soil surface) of the trunks on trees grafted onto MM106 rootstocks (Fig. 3), but on trees grafted onto M26 rootstocks the upper sample of the trunk contained significantly fewer larvae than the middle and lower portions of the trunk (F = 5.61; df = 2,6; P = 0.0423) (Fig. 3). No significant relationship was found between the number of larvae recovered and the diameter of the trunk, main or sub-main lateral limb they were recovered from.

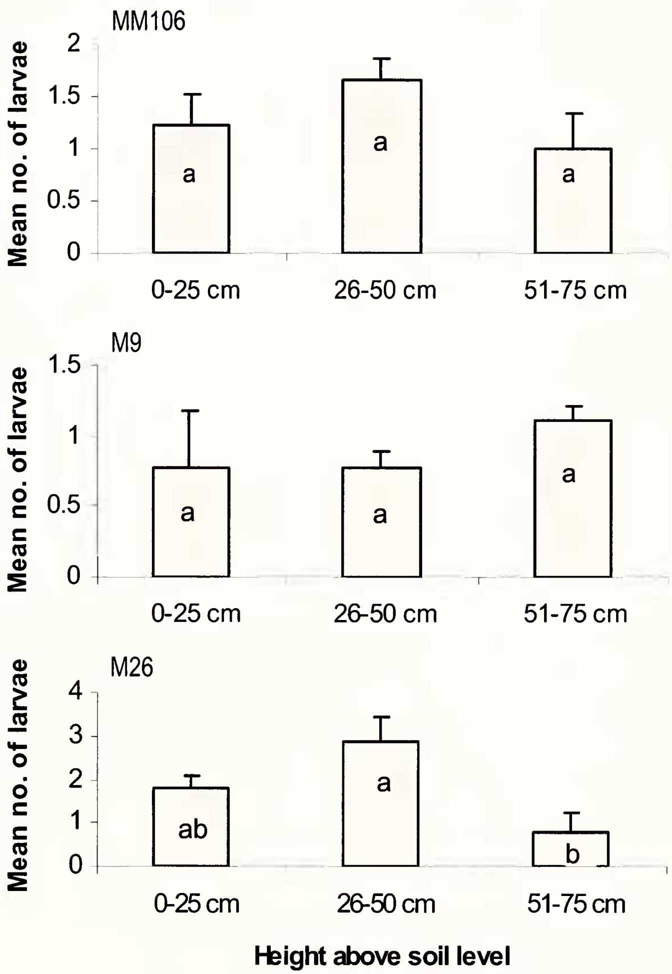

Figure 3. Within-tree spatial distribution of the small red-belted clearwing borer, *S. myopaeformis* larvae infesting the trunk of Mondial Gala apple cultivar grafted on MM106, M9 and M26 apple rootstocks at three different heights above soil. Means with the same letters are not significantly different using LSD.

DISCUSSION

In the present study, one application of an insecticidal paint composed of a mixture of Durusban (organophosphate insecticide), petroleum oil and hydrous copper sulfate caused a significant reduction in this insect for at least one-year. The other management practices had significant, but less impact on larval numbers. There are also disadvantages to their use. Using wire to mechanically control larvae is laborious and it is difficult to remove all larvae that can infest not only the trunk, but also main and sub-main lateral branches. Mounding soil and wrapping a veil of cloth around the exposed rootstocks will probably not prevent oviposition on main and sub-main branches. Young and Tyler (1983) showed that mounding soil around the exposed rootstock promoted the development of roots from burr knots. Riedl *et al.* (1985) reported that burying rootstocks with infested burr knots prevented the emergence of dogwood borer adults and further infestation of them. In the present study, it was found that some rootstocks such as M26 harbored more larvae of *S. myopaeformis* on portions of the trunk that were above the graft union (26-50 cm). This semi-dwarfing rootstock was noticed to have more burr knots at this portion of the trunk. Young and Tyler (1983) recommended that apple trees propagated on clonal rootstocks should be grafted no higher than 20-25 cm above the nursery roots, or that the new trees be planted deep in the soil to control dogwood borer. This would not entirely resolve the problem of *S. myopaeformis* infestation of burr knots as some cultivars of apple propagated on clonal rootstocks (such as MM106, M9 and M26 in the present study) tend to produce burr knots on the trunk and scaffold limbs, and these are also subject to infestation by the RBB. Earth and cloth guards to prevent the insect from ovipositing on the trunk may prevent already present RBB from emerging as adults but may also protect already present eggs and larvae from predation and parasitism and create optimal conditions for their development.

ACKNOWLEDGEMENTS

We acknowledge Mohannad Al-Akash for statistical analysis and Ali Rafae'a for his field assistance. This research was funded by the Deanships of Research in both Al-Balqa' Applied University and University of Jordan.

REFERENCES

Al-Antary, T., M. Ateyyat, and A. Al-Rafae'a. 2004. Clearwing borer in apple orchards in Ash-Shoubak. Al Mohandes Al-Ziraie 78: 49-51.

Ateyyat, M., T. Al-Antary, and A. Al-Rafae'a. 2005. Control strategies of clearwing borers in Ash-Shoubak. Al Mohandes Al-Ziraie 79: 23-25.

Abd Elkader, S. and S. Zaklama. 1971. The chemical control of the apple clearwing *Synanthedon myopaeformis* Bork.moth (Lepidoptera: Aegeriidae). Agricultural Research Review 49: 71-76.

Balazs, K., G. Bujaki, and K. Farkas. 1996. Incorporation of Apple Clearwing (*Synanthedon myopaeformis* Bork.) control into the IPM system of apple. IOBC wprs Bulletin 19: 134-139.

Bergh, J.C. and T.C. Leskey. 2003. Biology, ecology, and management of dogwood borer in eastern apple orchards. The Canadian Entomologist 135: 615-635.

Deseo, K.V. and L.A. Miller. 1985. Efficacy of entomogenous nematodes, *Steinernema* spp., against clearwing moths, *Synanthedon* spp., in north Italian apple orchards. Nematologica 31: 100-108.

Dickler, V. 1976. Zur Biologie und Schädwirkung von *Synanthedon myopaeformis* Bork (Lepid.: Aegeriidae), einem neun Schädling in Apfldichtpflanzungen. Zeitschrift für Angewandte Entomologie 82: 259-266.

Kain, D. and R. Straub. 2001. Status of borers infesting apple burr knots and their management in New York orchards. New York Fruit Quarterly 9: 10-12.

Jandel Scientific 1992. TableCurve Automated Curve Fitting Software. User's manual. v. 4 for Windows. San Rafael, California.

Maini, S. and E. Pasqualini. 1980. *Conopia (=Synanthedon) myopaeformis* Bkh. (Lepidoptera: Sesiidae) in Emilia Romagna segnalata mediante trappole a feromone sessuale sintetico. Bollettino dell'Instituto di Entomologia "Guido Grandi" della Universita degli Studi di Bologna 35: 181-188.

Mustafa, T. and N. Sharaf. 1994. Insects of Fruit Trees: Woody Trees and Ornamentals, Practical Manual. Dar Honnien Publishers, Amman.

Pfeiffer, D. and J. Killan. 1999. Dogwood borer (Lepidoptera: Sesiidae) flight activity and an attempt to control damage in 'Gala' apples using mating disruption. Journal of Entomological Science 34: 210-218.

Philip, H. 2006. Apple clearwing moth found in BC. Boreus, Newsletter of the Entomological Society of British Columbia 26: 20.

Riedl, H., R. Weires, A. Seaman, and A. Hoying. 1985. Seasonal biology and control of the dogwood borer, *Synanthedon scitula* (Lepidoptera: Sesiidae) on clonal apple rootstocks in New York. The Canadian Entomologist 117: 1367-1377.

Rom, R.C. 1970. Burr knot observations on clonal apple rootstocks in Arkansas. Fruit Varieties Horticultural Digest. 24: 66-68.

Rom, R.C. 1973. Burr knot characteristics of six clonal apple rootstocks. Fruit Varieties Journal 27: 84-86.

SAS, 2001. SAS version 8. SAS Institute Inc., Cary, NC, USA.

Sontgen, J.T. and C. Sengonca. 1988. Beobachtungen zum Auftreten von Parasitoiden des Apefelbaumglasfluglers, *Synanthedon myopaeformis* (Borkh.), in Nordrhein. Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie 6: 262-266.

Warner, J. and S. Hay. 1985. Observation, monitoring, and control of clearwing borers (Lepidoptera: Sesiidae) on apple in central Ontario. The Canadian Entomologist 117: 1471-1478.

Weirs, R. 1986. Five years research and experience with control of dogwood borer and related burr knot problems. Compact Fruit Tree 19: 86-90.

Young, A. and R. Tyler. 1983. Burr knot control on apple. HortScience 18: 921-922.